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COMBUSTION-ENGINED SETTING TOOL

The present invention relates to a combustion-engined tool referred to in the preamble of claim 1. Such setting tools can be driven with gaseous or liquid fuels which are combusted in a combustion chamber and drive a drive piston for fastening elements.

Generally, the problem with fuel consists in admixing, in each operational cycle, of a proper amount of air or oxygen, which constitutes oxidation means, to the fuel. The amount of oxygen, which is available for combustion, depends to a great extent on the surrounding temperature, air pressure, and air humidity. The necessary amount of fuel varies within a wide range, dependent on the above-mentioned parameters, up to 40% in an extreme case. The variations of the amount of fuel adversely affect the combustion of the air-fuel mixture when the air-fuel mixture contains too much fuel or too little fuel.

DE-42 43 617 A1 already discloses a setting tool in which in each working cycle, a gas inlet valve opens mechanically so that fuel is fed from a fuel source into a storage space that communicates with the surrounding air. This connection insures that pressure and, if necessary, temperature is (are)

equalized with that (those) of the surrounding air, so that a proper air-fuel mixture reaches the combustion chamber. The fuel is fed from this storage space at a predetermined time.

The drawback here consists in that the connection with the surrounding air can lead to loss of fuel. Further, the pressure in the metering chamber is not controlled.

EP-0 597 241 B1 discloses a combustion-engined setting tool in which fuel is fed from a fuel source to the combustion chamber through a normally-closed, solenoid-controlled valve. The excitation of the solenoid is effected electronically by a switching circuit in response to actuation of a switch, with the valve being open at a controlled, predetermined time interval to enable feeding fuel from a fuel source to the combustion chamber.

The drawback here consists in that at a varied admission pressure in the fuel source, the flow velocity of fuel varies, and a precise amount of fuel cannot be metered out.

An object of the invention is to develop a setting tool of a type discussed above in which the above-mentioned drawbacks are eliminated. This is achieved, according to the invention by features recited in claim 1 of which the following features are of a particular importance.

According to claim 1, it is sufficient when in the tool there is available a metering device that meters out the required fuel volume in form of a plurality of small, equal volume, separate portions. The metering takes place in accordance with the calculated number of separate portions. By changing the number of separate portions, the metered amount can be regulated. The feeding of the fuel from the fuel source to the combustion chamber is effected rhythmically or in form of pulses. With the inventive metering device, a very precise metering of both liquid and gaseous fuels is achieved.

According to an advantageous embodiment of the setting tool, there is provided, in the setting tool, sensor means, e.g., sensors for determining measurement data, e.g., the tool temperature, the surrounding temperature, the humidity of the surrounding air, and/or the type of the constructional component. The acquired data are communicated from the sensor means to the

control device which determines, based on the acquired data for each following operational cycle, the number of separate portions that must be fed from the fuel source into the combustion chamber. The control device takes over the control of the metering device, monitoring that a correct number of separate portions is maintained.

Preferably, the metering device is associated with a counter that calculates the number of already measured and metered out separate portions. Ideally, the counter transmits the acquired data to the control device, so that, if necessary, adaptation of the number of separate portions still to be dispensed by the metering device, can be effected.

Ideally, for metering separate volumes, the metering device includes at least one metering chamber. The metering chamber has at least one inlet for admitting fuel into the metering chamber and at least one outlet for feeding fuel to the combustion chamber. Preferably, the inlet and outlet are closed by closing means such as, e.g., a check valve, a flap valve, or the like. The metering device can have more than one metering chamber, whereby a separate portion is formed of the volumes or at least partial volumes of separate metering

chambers. Preferably, when there is provided a plurality of metering chambers, they are arranged annularly about a common central axis. The advantage of annular arrangement of metering chambers consists in that all of the metering chambers can be closed by one and the same closing member arranged in front of the inlets of all of the chambers, and by one and the same closing member arranged in front of the outlets of all of the chambers. The closing members are preferably formed as rotationally-symmetrical members, with the metering chambers being arranged along a circle. For opening and closing of the metering chambers, the disc-shaped closing members have each at least one opening movable by or, more precisely, rotatable past respective inlets or outlets of the metering chambers. When the opening of the disc-shaped closing members pass by the inlets or the outlets of respective metering chambers, the respective metering chambers open at respective inlets or outlets, so that fuel can be admitted into the respective chambers or be expelled from the respective chambers. The disc-shaped members, which can be driven, e.g., by a stepped motor, can be provided each with circular, segment-shaped slots, with the slots of the two disc-shaped members being offset relative to each other by 180°. The disc-shaped members are arranged, in the axial direction in front of and

behind the metering chambers. With this arrangement of slots, half of the chambers will have their inlet opened, and half of the chambers will have their outlet opened, so that all of the chambers are either connected with the fuel source or are connected with the combustion chamber. As soon as the inlets of the respective chambers open, the respective metering chambers are filled with a predetermined amount of fuel. When the outlets of the respective metering chambers open, the predetermined amount of fuel flows to the combustion chamber. The metered-out amount of fuel can be controlled by controlling the number of revolutions of the stepped motor. The metered-out amount of fuel and, thus, the number of separate portions, can be easily controlled by controlling the operation of the stepped motor with the control device. In order to insure that there is provided sufficient time for the fuel to flow in the metering chambers and to flow out therefrom, a provision of a certain minimal number of metering chambers can be advantageous. When, e.g., eight metering chambers are provided in the metering device, the time for filling/evacuation of the metering chambers, at the same metering frequency, in four time exceeds the time for filling/evacuation of the metering chambers of a metering device provided only with two metering chambers. Instead of a rotational movement

of the disc-shaped closing members, in front of and behind the metering chambers arranged along a circle, there can be used a linear reciprocating movement or a pivotal movement between two angles when the metering chambers are arranged linearly. When a linear arrangement of the metering chambers is elected, the reciprocating linear movement or the pivotal movement can be effected using a solenoid.

Instead of the displaceable disc-shaped members, e.g., the metering chambers can be made displaceable relative to the stationary closing disc-shaped members. Thereby, the number of displaceable parts is reduced.

The metering device can have only one stationary metering chamber with a check valve provided in both the inlet and the outlet (so that flow of fuel only in the direction toward the combustion chamber is possible). An oscillating displacement body (e.g., a piston, a diaphragm, etc…) insures that a predetermined amount of fuel, which is determined by displacement volume of the displacement body, is either fed into the metering chamber or is expelled therefrom.

In the supply conduit section of the metering chamber, at least one check valve is so arranged that the fuel can flow only in the direction toward the metering chamber. In the discharge conduit section of the metering chamber, the check valve is so arranged that the fuel can flow only from the metering chamber in the direction toward the combustion chamber, but not in the opposite direction back into the combustion chamber. Further, when the displaceable body is located in the metering chamber, its volume changes periodically by a precisely predetermined amount. The displaceable body can be driven or displaced, e.g., by a drive motor controlled by the control device. With the displacement of the displaceable body, a corresponding amount of fuel is pressed out of the metering chamber (upon increase of the displacement volume) or the corresponding amount is aspirated into the metering chamber (upon reduction of the displaceable volume). The number of strokes or pulses of the displaceable body determines the number of the separate portions of fuel.

According to an advantageous embodiment of the present invention, the control device includes a data processing unit for evaluation and processing the acquired parameters. This has an advantage that in the data processing unit, a known data pattern can be stored, and the predetermined metering amounts, i.e.,

the number of separate portions, can be associated with the data pattern. The data processing unit also permits to accelerate the data processing speed and the output of the commands to the metering device. The data processing unit can be formed, e.g., as a microprocessor, or as a microprocessor in combination with other electronic components.

Further advantages and features of the invention follow from subclaims, the following description, and the drawings. The drawings show four embodiments of the invention.

The drawings show:

Fig. 1 a schematic partial cross-sectional view of a setting tool according to the present invention;

Fig. 2 a schematic cut-out of the inventive setting tool of Fig. 1 according to a first embodiment;

Fig. 3 a schematic cross-sectional view along line II-II in Fig. 2:

Fig. 4a a schematic cut-out view corresponding to that of Fig. 2 of a second embodiment of the inventive setting tool according to

the present invention, with the displaceable body movable in a first direction;

Fig. 4b a schematic cut-out view of the second embodiment of the setting tool according to the present invention with the body movable in a second direction;

Fig. 5a a schematic cut-out cross-sectional view corresponding to that of Fig. 2 of a third embodiment of the inventive setting tool according to the present invention with the displaceable body movable in a first direction;

Fig. 5b a schematic cut-out view of the setting tool according to the present invention of Fig. 5a but with the displaceable body movable in a second direction;

Fig. 6a a schematic cut-out cross-sectional view of a fourth embodiment of the inventive setting tool according to the present invention with the displaceable body movable in a first direction; and

Fig. 6b a schematic cut-out of the setting tool according to the present invention of Fig. 6a but with the displaceable body movable in a second direction.

In Figs. 1-3 a first embodiment of a setting tool 10 according to the present invention, is shown in its initial or idle position. In this embodiment, the setting tool 10 operates on a fuel gas. The setting tool 10 has a housing 14 in which there is located a setting mechanism that drives a fastening element (not shown) in a constructional component (likewise not shown) when the setting tool 10 is pressed against the constructional component.

The setting mechanism includes, among others, a combustion space or combustion chamber 13, a piston guide 17, in which a drive piston 16 is displaceably supported, and a bolt guide 18 in which a fastening element can be guided, an where the fastening element is displaceable and can be driven in a constructional component by a forward-moving, setting direction-end of the drive piston 16. The fastening elements can be stored, e.g., in a magazine 19 attachable to the setting tool 10.

In this embodiment, an ignition unit, e.g., a spark plug 23 is located in the combustion chamber 13 for ignition of a fuel gas-air mixture which is brought in to the combustion chamber 13 for a setting process. The fuel gas is fed into the combustion chamber 13 from a fuel reservoir or fuel source 11 through a fuel conduit 12. The flow direction of the fuel gas from the fuel source 11 into the combustion chamber 13 is shown with arrow 26 in Fig. 1.

In the fuel supply conduit 12, there are located an electronically controlled metering device 30 and a counter 21 such as, e.g., a flow meter, which are located in the flow direction of the fuel gas in a row one after another.

The inventive setting tool 10 further includes an electronic control device 20 which is connected by an electrical conductor 47 with a power source 27, e.g., a battery or an accumulator.

The control device 20 can be provided, e.g., with a microprocessor in which a control program for one or several functions of the setting tool 10 can run. The control device 20 can control metering of the fuel by controlling the electronic metering device 30. The fuel will be fed into the combustion

chamber 13 from the metering device 30 in form of n-number of separate fuel portions.

The control device 20 is connected with the metering device 30 by an electrical conductor 44 and is connected with the flow meter 21, which located downstream of the metering device 30, by an electrical conductor 41. An electrical conductor 43 connects the control device 20 with the spark plug 23. An electronically operated switch means or a trigger switch 25 is arranged on a handle 15 of the setting tool 10 and is connected with the control device 20 by an electrical conductor 45. The control device 20 can also process measuring data and parameters of different sensors such as, e.g., a sensor 22 for sensing air pressure and air humidity. The sensor 22 is connected with the control device 20 by an electrical conductor 42. It should be noted that the electrical conductors 41, 42, 43, 44, 45, 47 can serve for both supplying the electrical energy and data transmission. Other sensors, besides the sensor 22, can transmit data to the control device 20. The other sensors can sense other parameters of the setting tool such as, e.g., temperature, position of the piston, etc…

Figs. 2-3 show the structure of a first embodiment of the metering device 30. The metering device 30 has a housing 54 and at least one metering chamber 31′. In the embodiment shown in Figs. 2-3, eight metering chambers 31′ are provided in the housing 54. The metering chambers 31′ have a shape of a cylinder that extends along an axis 38 and is open at both ends opening, respectively, into an inlet 32 and an outlet 33. The inlet 32 is connected with a portion of the fuel conduit 12 leading from the fuel reservoir 11 (not shown in Figs. 2-3), whereas the outlet 33 is connected with a portion of the fuel conduit 12 leading into the combustion chamber 13 (likewise not shown in Figs. 2-3). In front of the ends of the metering chamber 31′, there are arranged, respectively, disc-shaped closing means 34 and 35 which are fixedly secured on an axle 40 for joint rotation therewith. The disc-shaped closing means 34, 35 have, respectively, passages 39, 39′ movable in front of the metering chambers 31′, opening the same into the inlet 32 and the outlet 33, respectively. The disc-shaped closing means 34, 35 are so arranged relative to each other that the passages 39, 39′ are located diagonally opposite each other. Thus, oppositely located chambers 31′ can be opened and closed, respectively, in opposite

directions (inlet direction and outlet direction). The axle 40 is driven by a motor 52, in particular, stepping motor, which is connected by an electrical conductor 44 with the control device 20 that controls the motor 52 and supplies it with energy. The motor 52 and the axle 40 provide for angular displacement of the disc-shaped closing means 34 and 35 relative to the stationary metering chambers 31′. Upon a single revolution of the closing means 34 and 35, each of the chambers 31′ once opens into the inlet 32 and once opens into the outlet 33 by respective passages 39, 39′ in the closing means 34, 35. In this way, upon a complete revolution of the closing means 34, 35, a volume of the metering chambers 31′ is metered exactly eight times and is displaced form the inlet 32 to the outlet 33. If all of the eight metering chambers 31′ are considered to constitute a single volume, then upon each revolution, a separate portion of the fuel is displaced from the inlet 32 to the outlet 33 of the metering device 30 and is metered out. The n-number in the case is one. The control device 20 can control the motor 52 of the metering device 30 dependent on the reading by one or more sensors 22 of the air pressure, air humidity, tool temperature, etc…, and provide for another value of n. In this way, the number of separate portions of fuel metered into the combustion chamber 13 can be so calculated that the

number of separate portions optimally adapted to the amount of oxygen entering the combustion chamber 13 (from the surrounding air or from a source of concentrated oxygen).

The flow meter 21 can monitor if the calculated amount of fuel indeed flows through the feeding conduit 12 into the combustion chamber 13. The data generated by the flow meter 21 are transmitted via the conductor 41 to the control device 20 which upon deviation from a set value, can correct the amount of fuel by changing the parameter n by controlling the operation of the metering device 30 with a corresponding signal that is communicated to the motor 52 via he conductor 44. By a pulsed delivery of fuel in form of separate portions n into the combustion chamber 13, a complete evaporation of the fuel is achieved as, e.g., with a time-controlled delivery when the fuel is fed into a combustion chamber with one surge.

The movable parts of the metering device 30 are sealed against each other by seals 53. Thereby, an uncontrolled overflow of fuel from the inlet 32 to the outlet 33 is thereby prevented.

Figs. 41 and 4b show a second embodiment of the metering device 30 according to the present invention for a pulsed delivery of fuel form the fuel reservoir 11. The metering device 30 has a housing 55 with a single metering chamber 31. The housing 55 has an inlet 32 which communicates with the fuel reservoir 11 via a section of the fuel conduit 12 leading from the fuel reservoir with reference numerals. The housing 55 also includes an outlet 33 that communicates with a section of the fuel conduit 12 leading to the combustion chamber 13 (likewise not shown with reference numerals). The inlet 32 can be closed by closing means 36, e.g., a flap valve located in the metering chamber 31, when a pressure built-up takes place in the metering chamber 31. However, the closing means 36 opens the inlet 32 when the pressure in the metering chamber 31 falls below the admission pressure (whereby the pressure, in case o f metering of a liquid fuel, always remains above the vaporization pressure so that the fuel is always in a liquid phase), and fuel can flow in the direction 58 into the metering chamber 1. The outlet 33 is closed from outside by appropriate closing means 37 which likewise can be formed as a flap valve. The closing means 37 opens the outlet 33 upon the built-up of pressure in the metering chamber 31, whereby the medium flows from the metering chamber

31 through the outlet 33 in the direction 59 to the combustion chamber. In the opposite direction, the closing means 37 closes the outlet medium-tight. A cylindrical space 61 is also formed in the housing 55 and which is at least open toward the metering chamber 31. A displaceable body 50 is located in the cylindrical space 61 and is sealed against the side wall of the cylindrical space 61 with at least one sealing member 53. The displaceable body 50, which can be formed, e.g., as a piston, is pivotally connected at its end remote from the metering chamber 31 with a driving rod, e.g., an actuation member 51 connected with a motorized drive 52 formed, e.g., as a stepped motor.

When the control device 20 (please see Fig. 1) communicates an actuation signal to the motorized drive 52 via the conductor 44 to cause delivery of n separate portions of fuel from the metering device 30, the motorized drive 52 would perform n revolutions, whereby the displaceable body 50 would be alternatively displaced n times in the direction 56 and n times in the direction 57. Thereby, a predetermined fuel volume would be aspirated n times through the inlet 32, upon respective opening of the flap valve 36, into the metering chamber 31 upon movement of the displaceable body 50 in the direction 57,

and would be expelled n times through the outlet 33 upon opening of the flap valve 37 when the displaceable body 50 is displaced in the direction 56.

The described metering device 30, which is shown here, likewise can be used in the setting tool 10 as shown in Fig. 1.

A further embodiment of the metering device 30 according to the present invention is shown in Figs. 5a and 5b. The metering device 30, which is shown in Figs. 5a, 5b, likewise has a housing 55, with a metering chamber 31 having an inlet 32 and an outlet 33 which are closable, respectively, by closing means 36 and closing means 37. The closing means 36 and the closing means 37 function in the same manner as the corresponding means 36 and 37 of the metering device 30 shown in Figs. 4a-4b.

The housing 55 has a through-opening 63 which is completely closed by a displaceable body 50'. The displaceable body 50' is formed as an elastic member, e.g., as dumbbell-shaped body with a rubber-elastic outer sheath. The displaceable body 50' is filled with an incompressible medium 60, e.g., a hydraulic oil or any other appropriate fluid. The displaceable body 50' is retained in the through-opening 62 with a press fit a portion of the displaceable

body 50' is located in the metering chamber 31, with the other portion being located outside of the housing 55. The portion of the displaceable body 50', which is located outside of the housing 55 seats on an operational member 51', e.g., a piston. The piston 51' is mechanically connected with a motorized drive 52, e.g., a stepped motor, by a driving rod 51. The motorized drive 52 induces the reciprocating movement of the operational member 51' as a result of which the displaceable body 50' is subject to periodical impacts. With each displacement of the displaceable member 51' in the direction 56, the displaceable body 50', which is filled with incompressible medium 60, is pressed into the metering chamber 31, which causes flow of fuel in the direction 59 through the outlet 33 and into the feeding conduit 12 to the combustion chamber 13 (not shown here). With each displacement of the displaceable member 51' in the direction 57, the displaceable body 50' returns to its initial condition. The closing means 36 opens, and fuel can flow in the direction 58 through the fuel supply conduit 12 from the fuel source 11 (not shown) into the metering chamber 31. With each revolution of the motorized drive 52, the operational member 51' is displaced once in the direction 56 and once in the direction 57. Thus, with each stroke of the operational member 51', a single

portion of fuel is fed into the metering chamber 31 and is expelled therefrom through the outlet 33.

For further explanation, the reference is made to the foregoing discussion.

A still further embodiment of the metering device 30 according to the present invention is shown in Figs. 6a-6b. In this embodiment, likewise a metering chamber 31 having an inlet 32 and an outlet 33 which are closed, respectively, in the inflow and outflow directions with respective closing means 36 and closing means 37, is located in a housing 55. The housing 55 has an opening 63 which is completely closed by a displaceable body 50", which is formed as a diaphragm. Medium flow through the diaphragm is not possible. An operating element 51", which is formed, e.g., as a piston, is connected, e.g., by gluing, with the diaphragm 50". The piston is again displaced in opposite directions with a connection rod 51 connected mechanically with the motorized drive 52 likewise formed as a stepped motor in this embodiment. When a control device (not shown) communicates an actuation signal to the metering device 30 or the stepped motor 52, displacement of the piston 51" in the

direction 57 takes place (Figs. 6b). The fuel flows in the direction 58 through the section of the feeding conduit 12 leading from the fuel reservoir 11 (not shown here, see Fig. 6b) with the closing means 36 being open, into the metering chamber. Upon rotation of the stepped drive 52 by half of a revolution, the piston 51" is displaced in the direction 56, with the displaceable body 50" being displaced in the same direction 56. Upon displacement of the displaceable body 50" in the direction 56, the closing means 36 closes the inlet 32, and the fuel flows in the direction 59 through the outlet 33, with the closing means 37 being opened. From the metering device 30, the fuel can flow through the respective section of the feeding conduit 12 (not shown) only toward the combustion chamber 13 (likewise not shown). By rotating the stepped drive 52 with N revolution, the separate portions of fuel can be metered out and fed into the combustion chamber.

For a further explanation, reference is made to the description above.

LIST OF REFERENCE NUMERALS

10. Setting tool
11. Fuel source
12. Fuel feeding conduit
13. Combustion chamber
14. Housing
15. Handle
16. Drive piston
17. Piston guide
18. Bolt guide
19. Magazine
20. Control device
21. Flow metering device
22. Sensing means, sensors
23. Ignition Unit, spark plug
25. Switching means, trigger switch
26. Flow direction of fuel
27. Power source, battery/accumulator

30. Metering device.

31. Metering chamber

31. Metering chamber

32. Inlet

33. Outlet

34. Disc-shaped closing means

35. Disc-shaped closing means

36. Closing means, valve flap

37. Closing means, valve flap

38. Chamber axis

39. Passage in 34

39'. Passage in 35

40. Axle

41. Electrical conductor (between 20 and 21)

42. Electrical conductor (between 20 and 22)

43. Electrical conductor (between 20 and 23)

44. Electrical conductor (between 20 and 30/52)

45. Electrical conductor (between 20 and 25)

47. Electrical supply (between 20 and 27)

50. Displacement body (piston element)

50'. Displacement body (bellows element)

50". Displacement body (diaphragm)

51. Operating element/connection rod for 50, 50', 50"

51'. Operating element for 50'/piston

51". Operating element for 50"/piston

52. Motorized drive

53. Sealing elements

54. Housing for 31'

55. Housing for 31

56. Displacement direction

57. Displacement direction

58. Direction

59. Direction

60. Incompressible medium

61. Cylindrical chamber

62. Opening

63. Opening